Light Beyond the Tube™

2014 DOE Solid-State Lighting R&D Workshop

Shaping the Lighting Experience With Spectral Control

Steve Paolini – CTO

Who Are We?

- **Our company:** Headquartered in San Francisco, CA since 2009
- **Our vision:** Develop the best linear lighting solutions
  - Ground-breaking design
  - Compelling economic value
  - Made in U.S.A.
- **Our platform:** Patented LED technology enables broad range of value-added applications
- **Our market:** 45% of all lighting
  - Consumes 10% of world's electricity

Agenda

- Introduction
- Illumination vs. Infotainment
- Electronic Illumination
  - Spectral Tuning and Manipulation
- Daylight – the gold standard
  - Spatial, Temporal, Spectral, Beam distribution
- Summary

Light for Illumination vs. Light for Infotainment

- Look at people, objects
- Less saturated colors
- Changes slowly
- Low spatial density
- High spectral density
- CRI – important
- Collimated, Diffuse

- Look at the light
- Saturated colors
- Changes fast
- High spatial density
- Low spectral density
- CRI – don’t care
- Collimated, Diffuse

- Electric light, Daylight

- TV, Rock Concert

Electronic Illumination

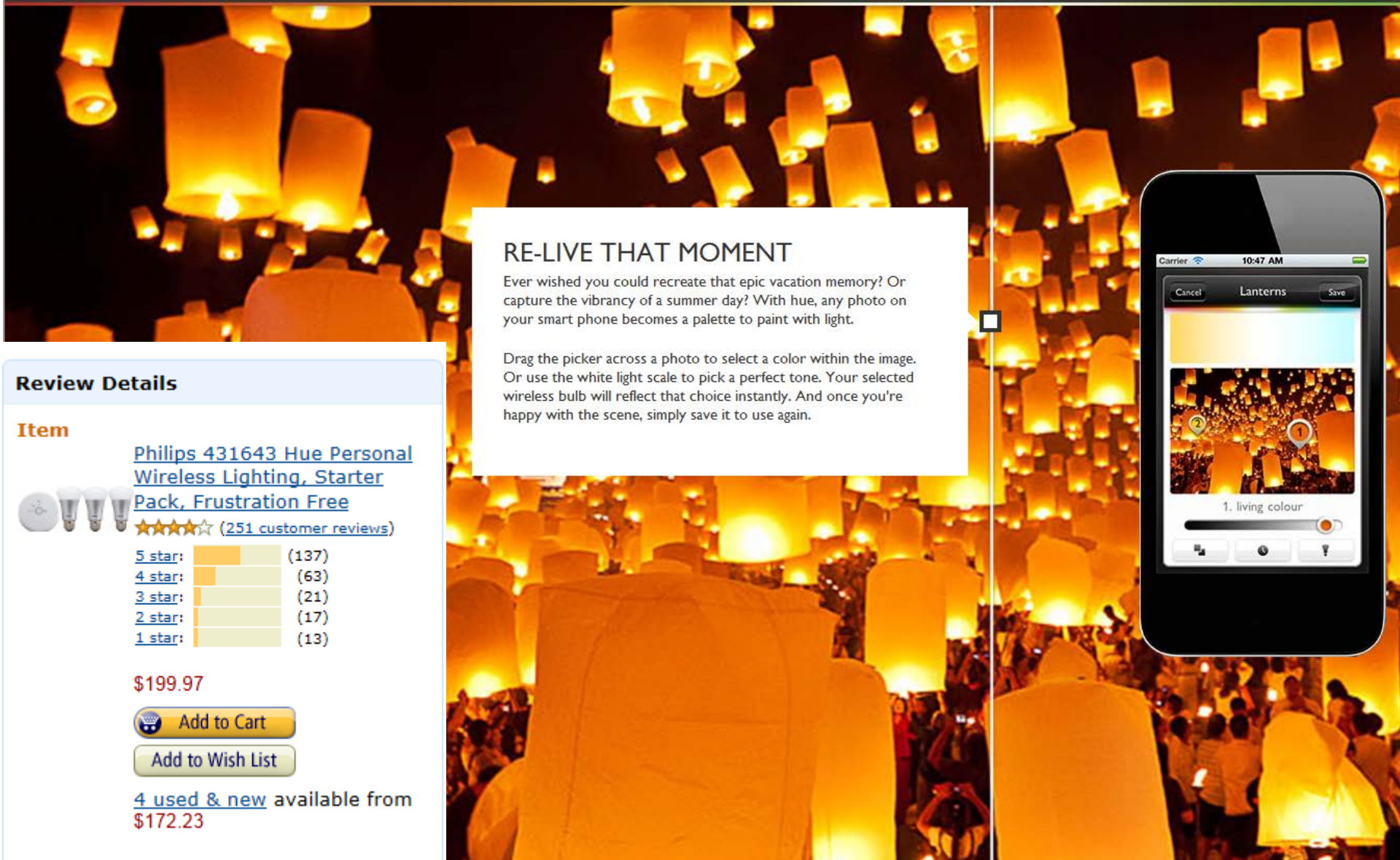
Products and Near Products

PHILIPS

hue PERSONAL WIRELESS LIGHTING

MEET HUE | GET STARTED | COMMUNITY

VIDEO | WAKE UP | AMBIENCE | SAFE AND SECURE | PHILIPS LIGHTRECIPES



RE-LIVE THAT MOMENT

Ever wished you could recreate that epic vacation memory? Or capture the vibrancy of a summer day? With hue, any photo on your smart phone becomes a palette to paint with light.

Drag the picker across a photo to select a color within the image. Or use the white light scale to pick a perfect tone. Your selected wireless bulb will reflect that choice instantly. And once you're happy with the scene, simply save it to use again.

Review Details

Item

Philips 431643 Hue Personal Wireless Lighting, Starter Pack, Frustration Free

★★★★☆ (251 customer reviews)

5 star:		(137)
4 star:		(63)
3 star:		(21)
2 star:		(17)
1 star:		(13)

$199.97

Add to Cart

Add to Wish List

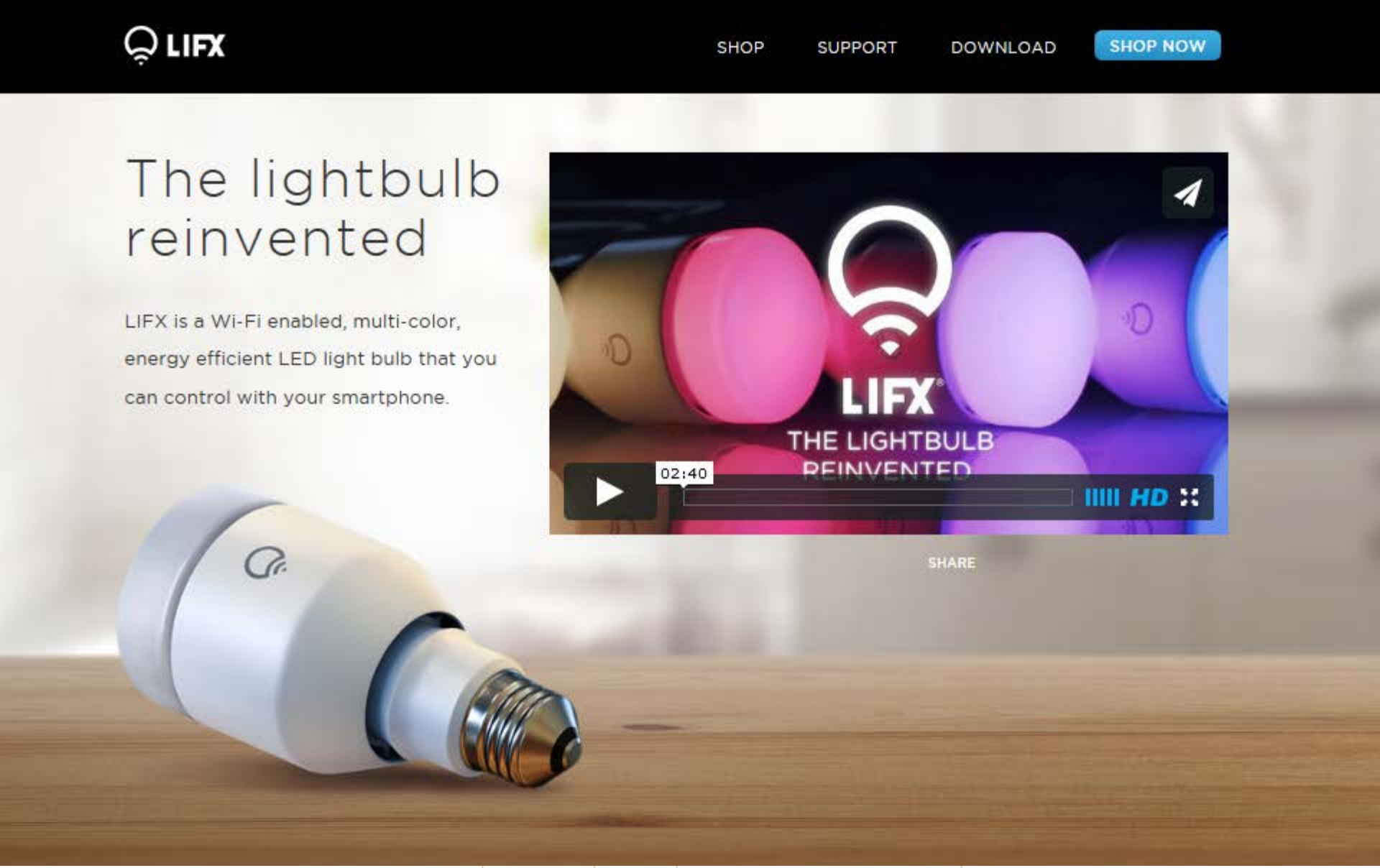
4 used & new available from $172.23


hue
PERSONAL WIRELESS LIGHTING

Aftermarket HUE Apps

- **f.lux** changes the color of a display by the time of day.
- **Ambify** adds music to light.
- **Goldee** adds dynamic effects by cycling through the colors in a photo.
- **Quick Hue** adds a simple interface and gesture commands for brightness, color, and scene changed.
- **Hue Scintillator** is an advanced color cycler adding speed, order, brightness, pattern, and other effects.
- **Hue Remote** adds voice command and simpiler controls.
- **Switches for Hue** simplifies “light recipes” to create color combinations, adjust individual lights, and switch everything on or off from the home screen.
- **Hue Disco** puts lights in party mode - custom color cycles, strobe effects, and react to music.
- **Magma Hue** is a simple color board and brightness slider.

- **Themes: simpler interface, dynamic, music**



LIFX: The Light Bulb Reinvented

by Phil Bosua

The transition from static lighting to tunable lighting is like the transition from black & white TV to color TV.

- Corey Egan, CEO

Initially, it's hard to conceptualize the value that adding color brings, but when experienced it's even harder to go back. A key success factor is that this capability is easily accessible by the user.

Lustr

Products | Support | Solutions | Installations | News

Lighting Fixtures → Selador Series → Lustr

Lustr

Finally -- bright, pure white from an LED fixture, plus cool hues and warm colors for natural skin tones.

Forums

Lustr | Tech Specs | Downloads & Software | Related Products | Testimonials

Lustr® is the white light specialist in the Selador® Series. Think watercolors – warm or cool pure white light slowly evolving into the softest tints and color shadings. In Lustr, the x7 Color System™ is optimized to produce theatrical-quality whites and tints that render pigments and skintones in their natural appearance. For key and fill light applications

COLOR

- Exclusive *x7 Color System*™ 7-color LED array
- Lustr – optimized for the best whites and tints
- Color rendering as high as 90 CRI
- Interacts seamlessly with conventional sources
- Achieve natural-looking 3200° – or any other Correlated Color Temperature white light from 800°K to 20,000°K
- Beautifully illuminates skin tones and other objects, for a natural appearance with high color rendering

OPTICAL

- Native tight beam spread of approximately 12°
- Secondary lenses install in fixture front to change distribution of light

CONTROL

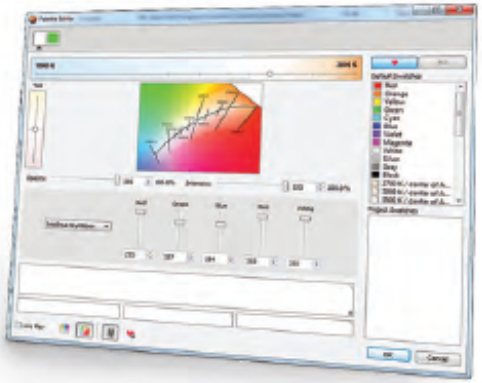
- DMX512 in and thru via 5-pin XLR connectors
- 8 channel control (7 color plus intensity)
- Intensity channel minimizes color shift during dimming
- 15-bit internal control for smooth low-end dimming

PHILIPS

COLOR KINETICS™

IntelliHue

Precisely Controllable Full Color and High-Quality White LED Light



SkyRibbon IntelliHue Powercore White Range Interface in ColorPlay 3

Groundbreaking IntelliHue color-control technology offers unprecedented color performance, precision, and range for both colored and white LED light. IntelliHue technology delivers enhanced spectral content for precise control of color, color temperature, and tint. With IntelliHue, you can easily target and precisely adjust millions of colors and shades of white light around the black-body curve.

For white light, IntelliHue's enhanced spectrum allows for:

- Precise color tuning in an expansive range extending from 2000 K (firelight) to 10000 K (blue sky) along the black-body curve
- Precise tinting and shading of white light points in a generous region extending above and below the black-body curve (+/- 0.06 Duv)
- An extremely high level of color consistency (<2 SDCM) in tandem with Chromasync, rendering color variations virtually imperceptible

IntelliHue combines all the benefits of IntelliColor, IntelliWhite, and Essential White technologies and makes them available in a single fixture, while adding an unprecedented ability to target and tint white-light color points.

INTELLIHUE
CK TECHNOLOGY

IntelliHue, an advanced approach to color control and mixing, produces an enhanced spectrum of precisely controllable light, including millions of saturated colors, pastels, and precisely controllable, high-quality white and tinted white light. By combining carefully selected channels of LED light sources, IntelliHue enables high-quality intelligent color and white light from the same fixture.

lumenetix

Home Products Technology Company Contact Us

Araya is a profound advance in the art and science of LED light illumination.

The araya Color Tuning Module and Light Commissioning Tool introduce new levels of precision, performance and consistency by accurately tuning LED light over a wide range of color temperatures (CCT). Integral to this system is patented software models and Closed Loop Control that provides accurate color points, exact color matching between luminaires and calibration to maintain color temperature over the life of the color tuning module.

		Tunable Color Temperature Range	
		1600–4000K	2700–6000K
Luminous Flux (Typical)	CTM 012	750	800
	CTM 019	950	1050
	CTM 032	1050	1200
Nominal Color Consistency (offset from CIE Black Body Locus)	CTM 012 CTM 019 CTM 032	Within ± 2 Standard Deviation of Color Matching (SCDM)	
Color Rendering Index	Ra @ 3000K	95	93
	Ra range	91–97	92–98
	R9 @ 3000K	91	90

@ Contact Us

Product Info and Downloads

Contact a Sales Rep

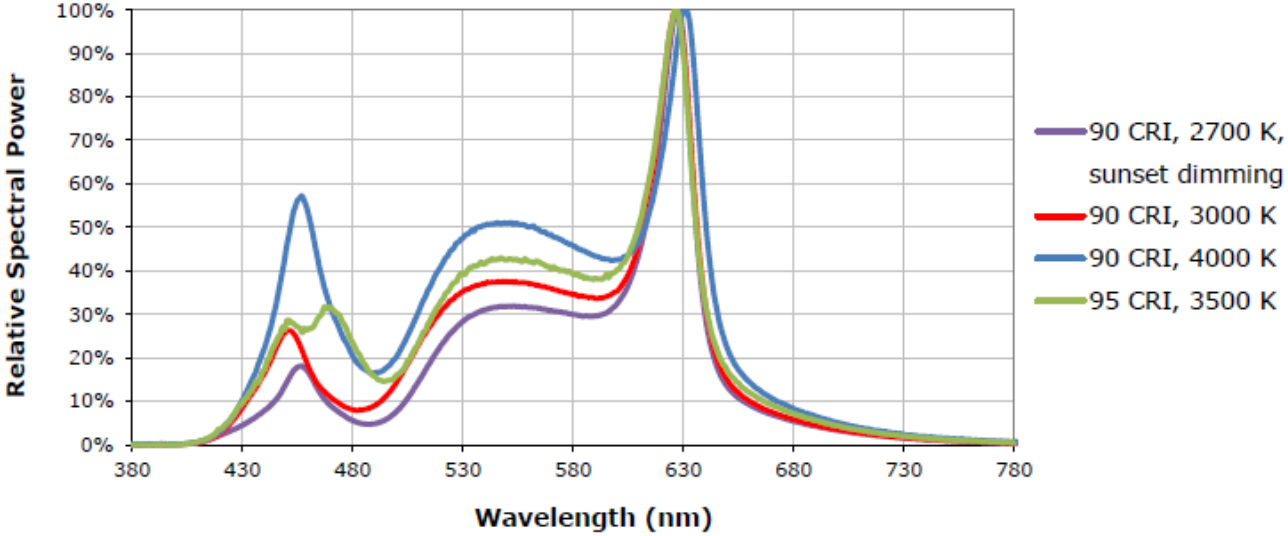
Light Commisioning Tool

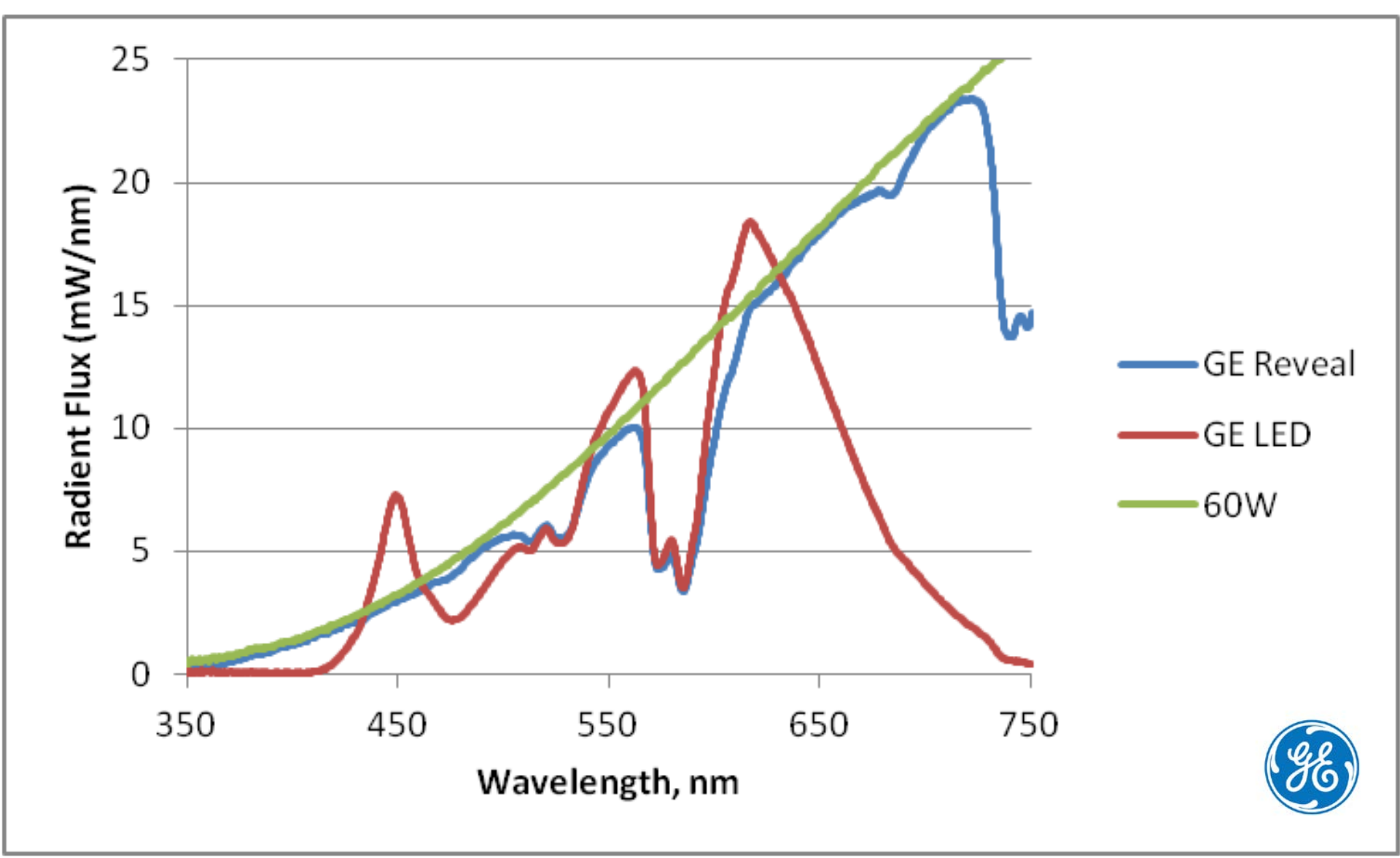
Cree® LMH2 LED Modules

LMH2 Light Source with Flat Lens

RELATIVE SPECTRAL POWER DISTRIBUTION

Test Conditions: I_F = 440 mA: 850 & 1250 lm WhiteLight & sunset dimming; I_F = 900 mA: 2000 & 3000 lm WhiteLight dimming; I_F = 940 mA: 2000 & 3000 lm sunset dimming; I_F = 940 mA: 4000 lm WhiteLight dimming; I_F = 1700 mA: 6000 lm WhiteLight dimming; Steady-state operation





	Lumens	opt-W	CCT	CRI	R9	x	y	V	mA	W
GE Reveal	588	3.74	2732	76	11	0.449	0.395	120	505	60.5
GE LED	636	2.25	2758	90	84	0.445	0.391	120	104	11.4
60W	818	4.58	2778	100	100	0.454	0.409	120	495	59.4

Definity Digital™

LightingScience®

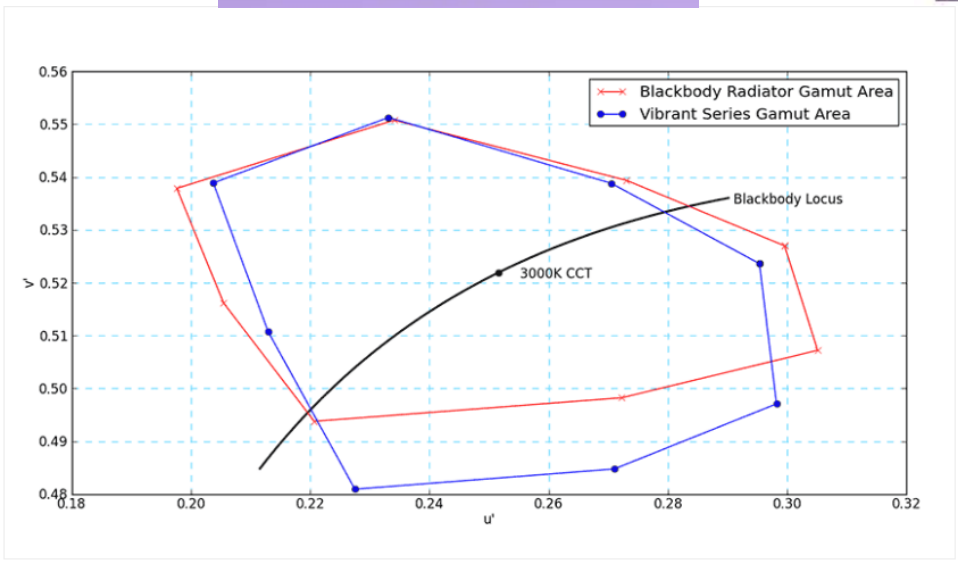


Figure 2. The gamut area of the Vibrant Series is not exactly the same as the blackbody reference so CRI by definition is less than 100, however the gamut area is larger and therefore has a higher GAI.

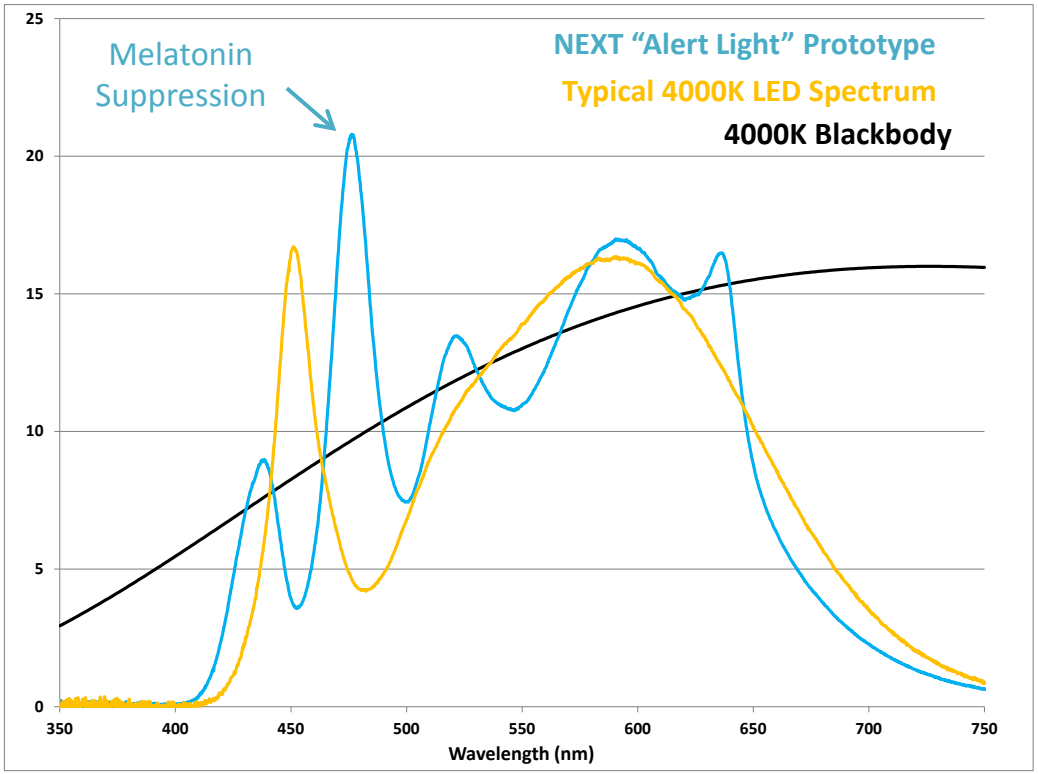
Color Rendering: A Tale of Two Metrics

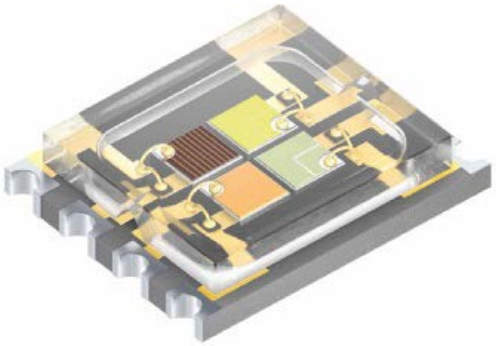
Mark S. Rea,* Jean P. Freyssinier-Nova

Lighting Research Center, Rensselaer Polytechnic Institute, Troy, NY 12180

Received 2 June 2007; revised 24 August 2007; accepted 5 September 2007

- 5-color LED tunable system prototype
- Technology allows broad spectral tuning and “designer spectrum” linear lighting products
- Example spectrum (4000K cyan-rich light) shown below





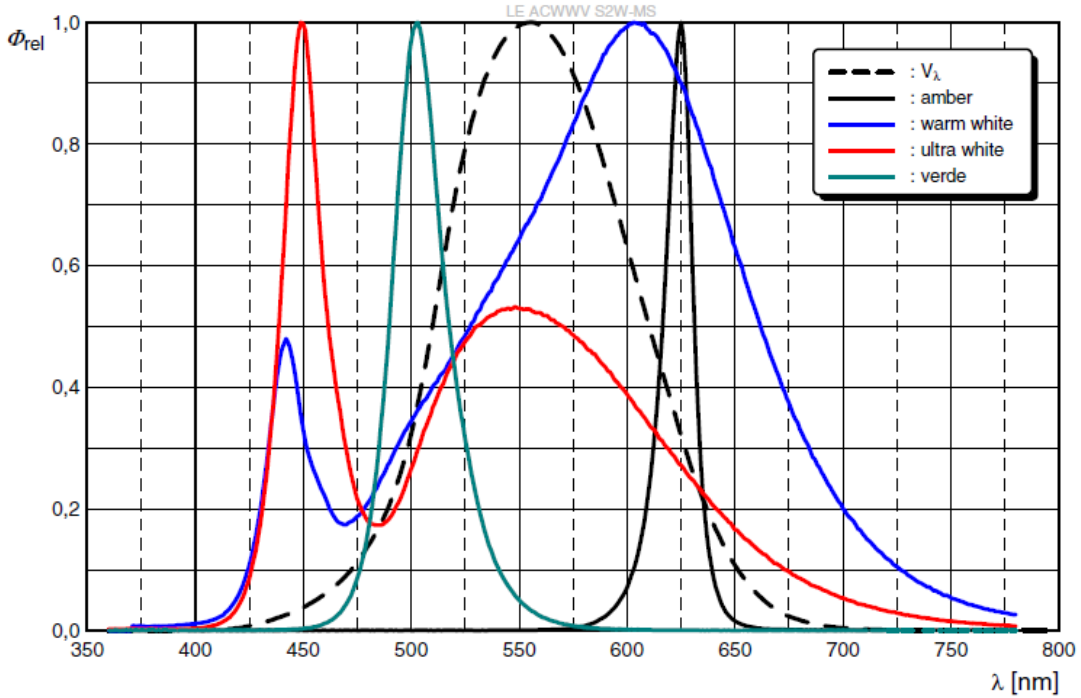
Technical data of the Osram Ostar Medical (LE ACW UWV S2W):

Footprint	5.9 mm x 4.8 mm
Height of housing	1.2 mm
Thermal resistance R_{th}	1.8K/W
Typical brightness	~ 180 lm (at 4,000 K) ~ 325 lm (at 5,000 K)
CRI	R_aR9 greater than 95
Other features	- Thin-film chip technology - Four chips in warm white and ultra white, verde (green) and amber (red)

Relative Spectral Emission[2) *page 23*]

V(λ) = spektrale Augenempfindlichkeit / Standard eye response curve

$\Phi_{rel} = f(\lambda)$, T_J = 25 °C, I_F = 700 mA



TELELUMEN

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Stay On Top of the Latest TeleLumen News...

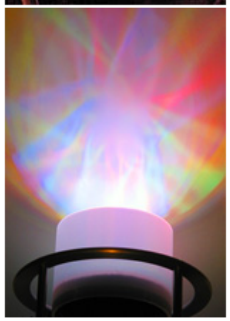
Telegraph, Telephone, Television... TeleLumen

Since the dawn of humankind, part of our innate nature is our awareness of our ability to "remember" and with it, a relentless need to "record" what we remember; to communicate our experiences to others when verbal communication fell frustratingly short.

Starting from 30,000 year old cave drawings, humans have devised ever more expressive and meaningful methods to record human experience. Over many centuries, this innate human need manifests itself again and again. From written language to drawing to Gutenberg's printing press, humans have devised increasingly immersive methods to convey a more compelling "recording" of human experience. With the dawn of electricity and radio, the concept of telecommunication became a reality. The Telegraph, the Telephone, and Television clearly stand out as landmark achievements to communicate words, sound and imagery in motion. Now, in the 21st Century, TeleLumen has developed the technology to record and playback light with new levels of fidelity, vividness and accuracy never before achieved.

The Technology of TeleLumen®

More than just LEDs, TeleLumen technology elegantly combines communication, control, and color intensity management to match what is found in nature. It literally unleashes 10 orders of magnitude more points of fidelity than conventional RGB systems.



The "Light Replicator" which reproduces with full fidelity, the color, intensity and seamless spectral change in the recording of light over time.

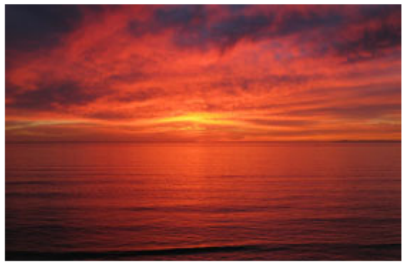
Learn more about TeleLumen technology in depth...

The Recording and Playback of Light

A simple gaze at these two images evokes two measurably different effects on our minds and bodies. This physical and psychological effect from immersive light affects not only humans but all living things.

The full fidelity of light, it's color, intensity and the subtlety of how it changes over time can now be captured in digital form, edited, enhanced, transmitted and replayed.

Learn more...

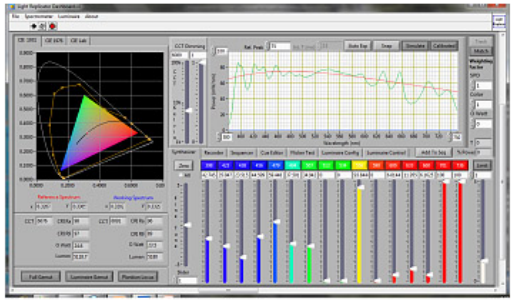


LumenScript: Complete Control of Light Recording

Light recordings are now possible through our breakthrough **LumenScript™** technology.

LumenScript technology can record time sequences from milliseconds to months (at 1,000 FPS!). From sunsets to candlelight to lightning, literally any light can be recorded, edited, slowed down, or enhanced to your purpose with **LumenScripts**. LumenScripts are small portable files that unleash the power of engineered light.

Learn more...



WHAT'S NEW

→ NEWS

→ NEWSLETTER

Start ▸ NEWS ▸ Image Engineering introduces prototype of LE7 with iQ-LED

Search...

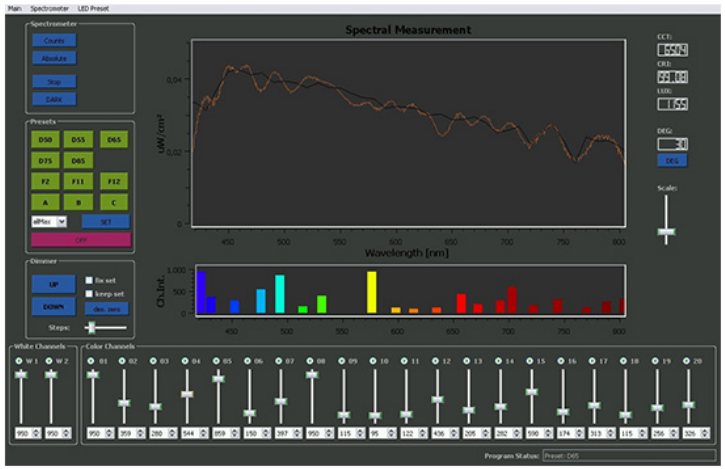
Image Engineering introduces prototype of LE7 with iQ-LED

Friday, 01 February 2013 21:03

A revolution in test chart illumination and camera calibration!

Do you want to perform your camera measurements using D65? And then D50 and your very own light source? What about if this would be possible without changing the light source or changing filter? What about if the accuracy of the standard light would be extreme high and you can change within a fraction of a second between them? Image Engineering presents the all new LE7 with the iQ-LED light source.

LE7 with iQ-LED and different illuminance



The user interface of the control software in prototype stage with light set D65

The iQ-LED is the latest development project of Image Engineering. It is a multi channel LED light source that gives you the possibility to generate the spectral characteristics of nearly every needed light source in just one device.

TOSHIBA
Leading Innovation »»

E-CORE™ [イー・コア] マルチカラーLEDシーリングライト

Multi Color CONTROL SYSTEM マルチカラーコントロールシステム

明るさ、光色が変えられます。

調光・調色

光色と明るさを自在に調節※1。シーンに合わせてお好みの設定に。

照明は夜点灯するものと思いがちですが、天候や間取りによっては昼間の補助としてもとても重要です。また、光の量や色は生活シーンをより快適な空間にする要素でもあります。調色、調光を上手く使い分けましょう。

光色(調色)


❶ 昼光色 すがすがしく、さわやか


❷ 昼白色 生き生きと、自然に


❸ 電球色 リラックス、くつろぎ

明るさ(調光)


❹ 明るさ50% 朝や夕暮れ前は、必要な分だけ点灯


❺ 明るさ20% 昼間はしっかり調光して省エネ点灯

※1:「調色」「調光」の操作には、「あとからリモコン」(別売)が必要になります。
リモコン送信器を使用せず、壁スイッチでのご使用の場合は「全光(昼白色100%点灯)」→「シーン1(昼白色約10%)」→「LED常夜灯」の順送り点灯となります。
※2:おすすめの音数は全光(昼白色100%点灯時)の明るさの時の目安です。■光色・電球色の場合は明るさの上限は、全光(昼白色)の約半分になります。

調色・調光は全304パターン

リモコンで光色と明るさを思いのまま

ON/OFFタイマー付
FRC-189T
マルチカラーLEDシーリングライト専用(同梱)

3250色の光色が選択できる「カラー」モード

あかりの色が七変化します **マルチカラー**

暮らしのアクセントに、光色を3250色の中から自在にセレクトできます。


静寂のひとときは青色で。心静かに思いをはせる空間を演出します。
明るさ:125lm/消費電力:1W
固有エネルギー消費効率:8.3lm/W


マリンブルー系のあかりはアクアリウムのような水と光を空間に創出します。
明るさ:565lm/消費電力:2.4W
固有エネルギー消費効率:23.5lm/W


色の光色に比べまぶたを透過しにくい。
隣に寝ている人を眩しさでおこさないようにしながら、夜間のちょっとした作業が可能です。※3
明るさ:440lm/消費電力:15W
固有エネルギー消費効率:29.3lm/W


RGB搭載ならではの黄色の空間も演出が可能に。
明るさ:640lm/消費電力:20W
固有エネルギー消費効率:32.0lm/W


ほのかに光るオレンジ系のあかりで、キャンドルが灯るような空間を演出。落ち着きの空間をムードあるディナーとともに。
明るさ:420lm/消費電力:16W
固有エネルギー消費効率:26.3lm/W

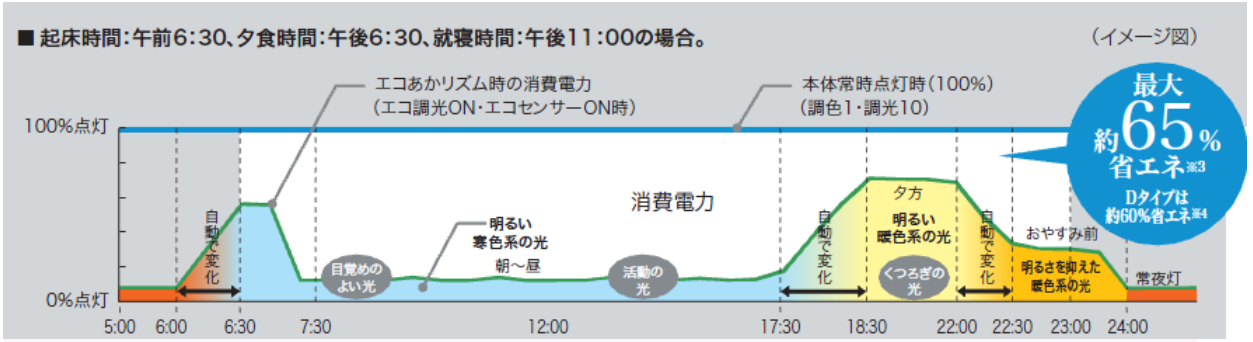

情熱の赤色の空間創出が可能です。今までにはない新しい空間創出でお好みのシーンに合わせてお楽しみいただけます。
明るさ:200lm/消費電力:12W
固有エネルギー消費効率:16.7lm/W


アロマキャンドルを灯すような神秘的な空間演出で、高貴な夜のひとときを。
明るさ:325lm/消費電力:20W
固有エネルギー消費効率:16.3lm/W

※3:当社評価試験による。

東芝ライテック株式会社　マルチカラーLED シーリングライトチラシ

業界最高水準の効率※1※2 83.6 lm/Wを実現。(DL-C603V)
シャープのLEDシーリングライト。




LED
ヨドバシカメラの
おすすめ畳数は
どこにも負けない
接客対応・商品知識
他店より高い商品がございましたらお
2700lm以上なら
3200lm以上なら
3800lm以上なら
Panasonic
省エネ!
リビング
調光し省エネ
スポットライト・間接光で
映画館のような臨場感を演出!
シアター照明
キラキラセードやさくら色の光で
お部屋の雰囲気を盛り上げます!
さくら色LED
HITACHI
Inspire the Next
日本製
LEDシーリング
業界トップクラス
驚きの大光量7,290lm
「あかりセレクト」で暮らしを演出
カラーLEDのリングで光のアクセント
¥54,800
ワイドリビングに最適
12畳まで
LED
made in Japan
¥33,200
SHARP
おウチまるごとLED
¥32,800
¥23,200
リビングに最適
10畳まで
簡単取付
LED照明
SHARP
¥20,200
子供部屋・寝室に最適
8畳まで
エコ技で省エネ
おウチまるごとLED
SHARP
¥17,000

Fraunhofer Institute, LEiDs GmbH ceiling tiles

– RGB and white LEDs simulate sky with moving clouds

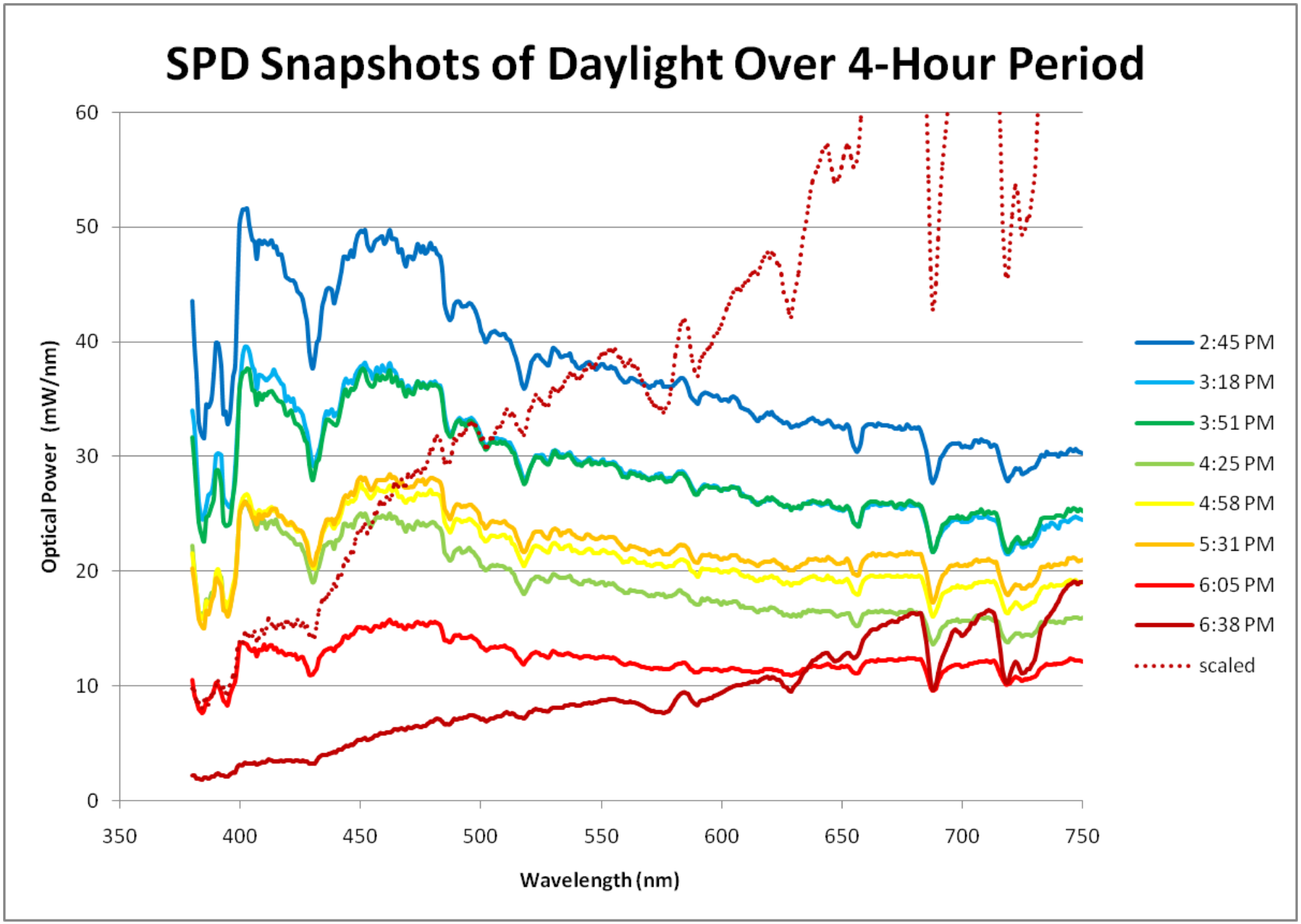
The dynamic luminous ceiling gives office staff the pleasant feeling that they are working under the open sky. © Fraunhofer IAO

http://www.fraunhofer.de/en/press/research-news/2012/january/sky-light-sky-bright.html

Sky Photos

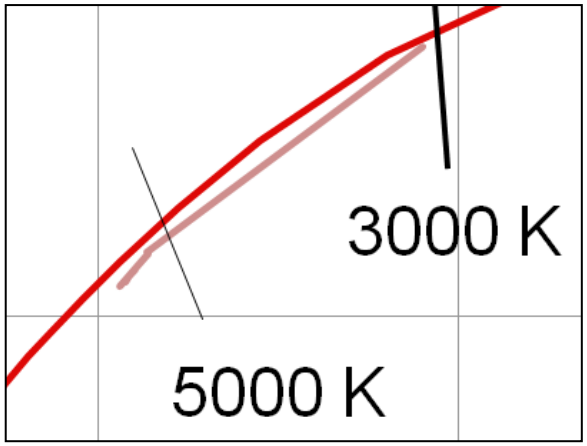
Daylight is not D65


LUMINE
UMINE2
Victoria



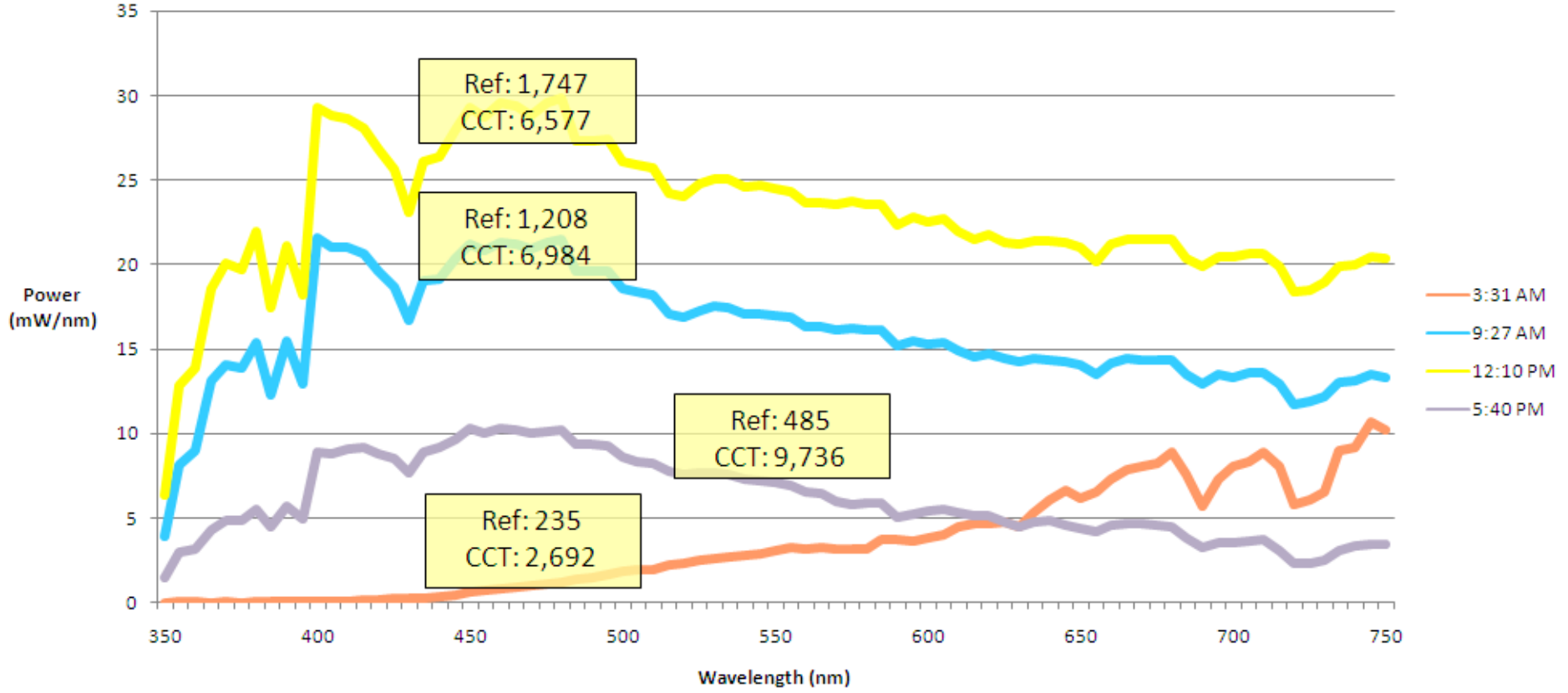
Recorded on Mt. Hamilton, CA at Lick Observatory, 9mar11 – courtesy Telelumen

Mt. Hamilton, San Jose CA, daylight, 9mar11						
time	x	y	CCT	CRI_Ra	CRI_R9	CQS
2:45:00 PM	0.307	0.311	7010	95	78	98
3:18:20 PM	0.309	0.312	6890	96	79	98
3:51:40 PM	0.31	0.314	6765	96	79	98
4:25:00 PM	0.306	0.309	7185	95	76	98
4:58:20 PM	0.311	0.315	6735	95	77	98
5:31:40 PM	0.314	0.319	6525	95	76	98
6:05:00 PM	0.314	0.319	6540	94	70	98
6:38:20 PM	0.39	0.38	3765	93	62	95



Sunlight Snapshots

Mt. Fuji, Full Day, 7/14/2011

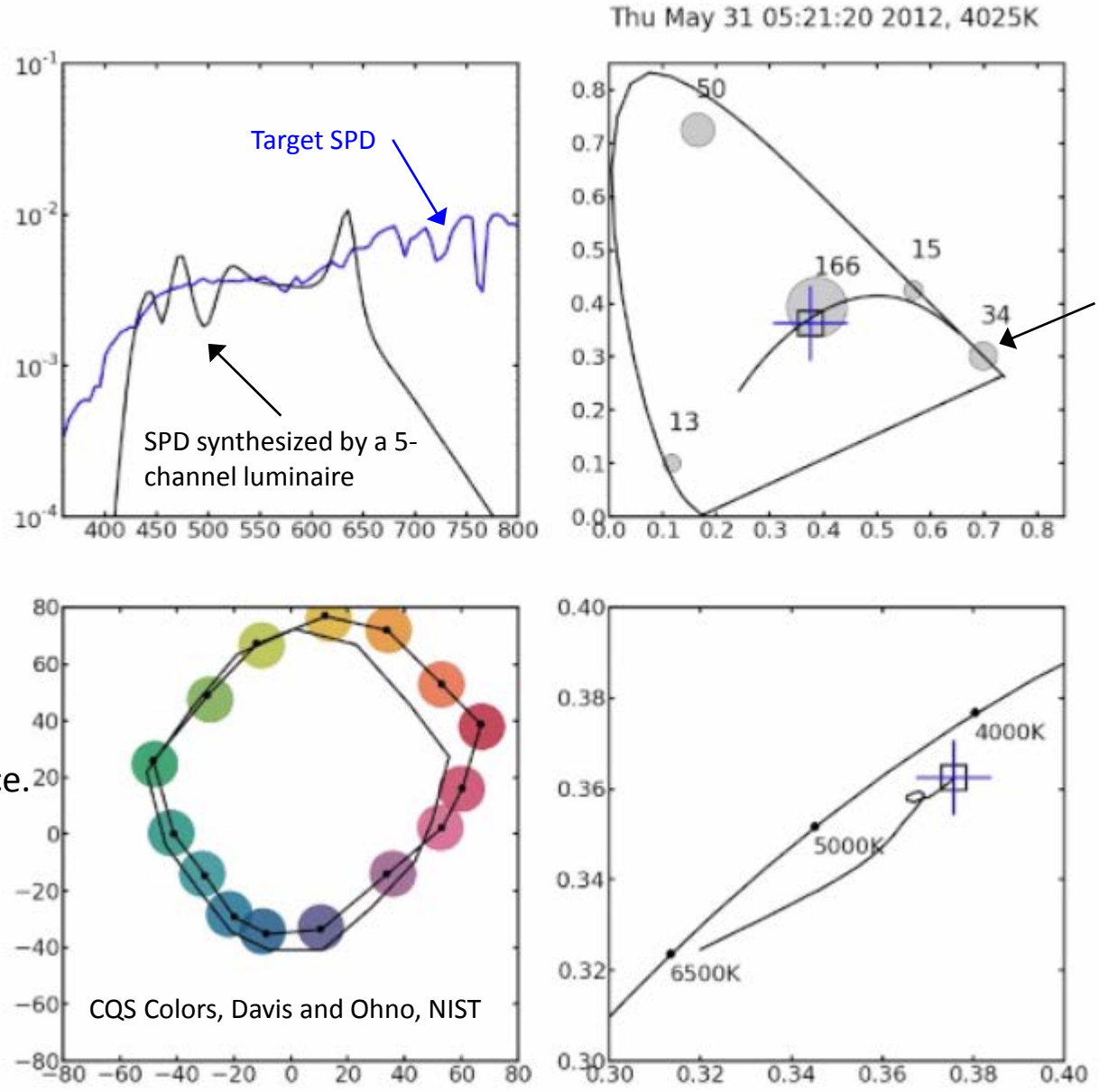


Valley of Fire, Nevada

Valley of Fire Playback Synthesis

- Choose a color set. In this case CQS
- Minimize RMS deviation of colors under target and synthesized light
- Works with any number of independent light sources. In this case 5.

Valley Sunrise at 5:21AM

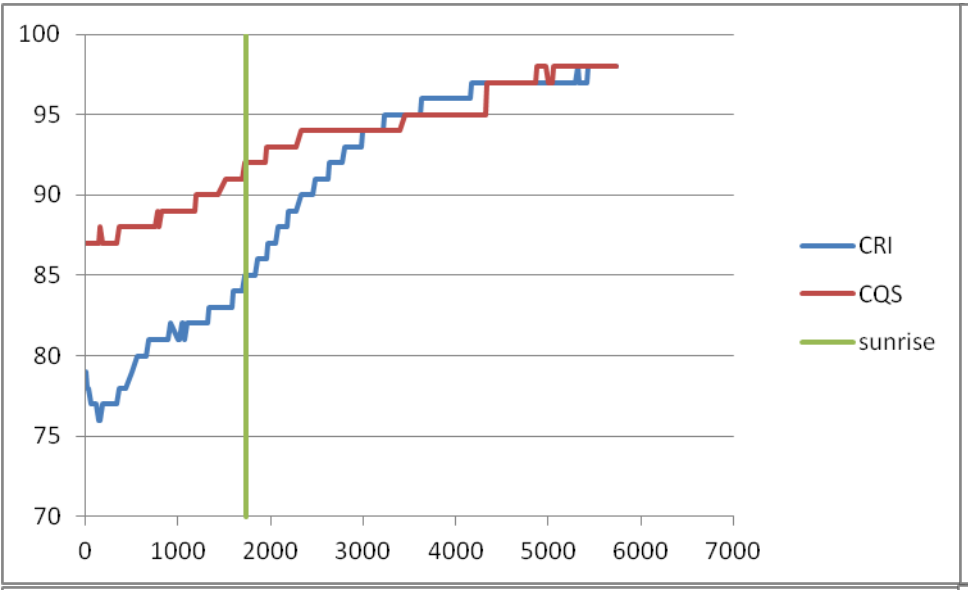


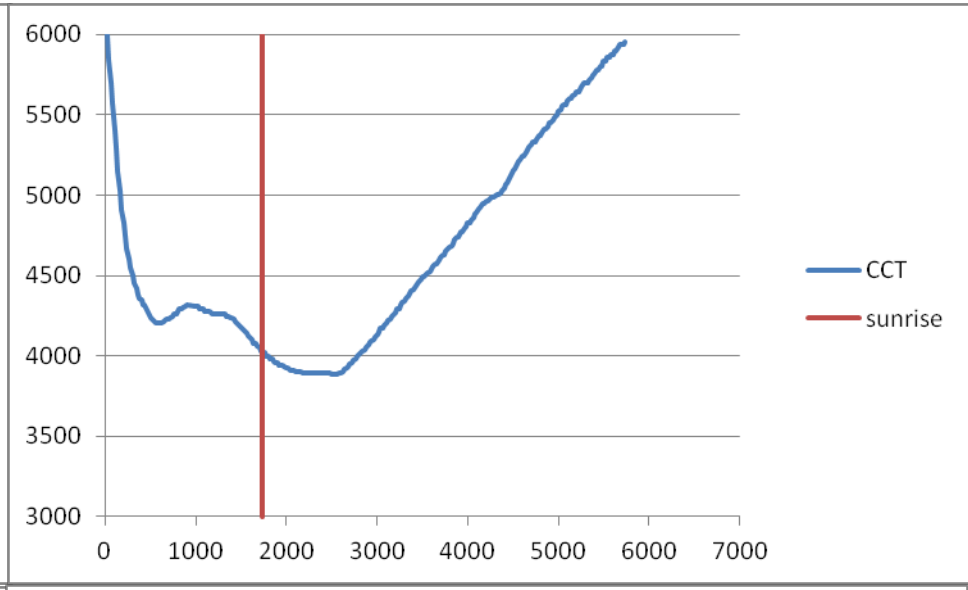
Areas of gray circles are proportional to lumens emitted by each channel

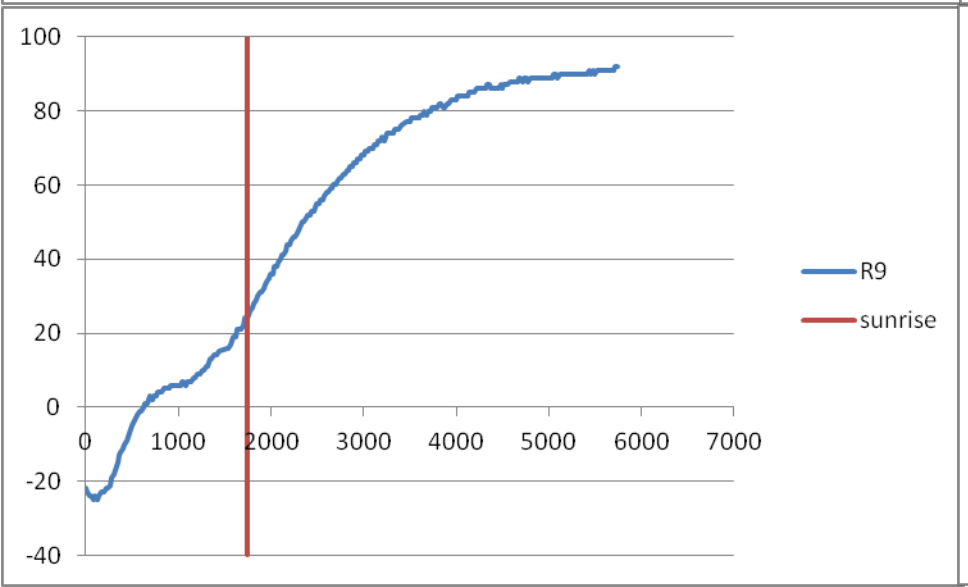
CQS colors illuminated by target light in La*b* color space. Circle radius is 3 JND.

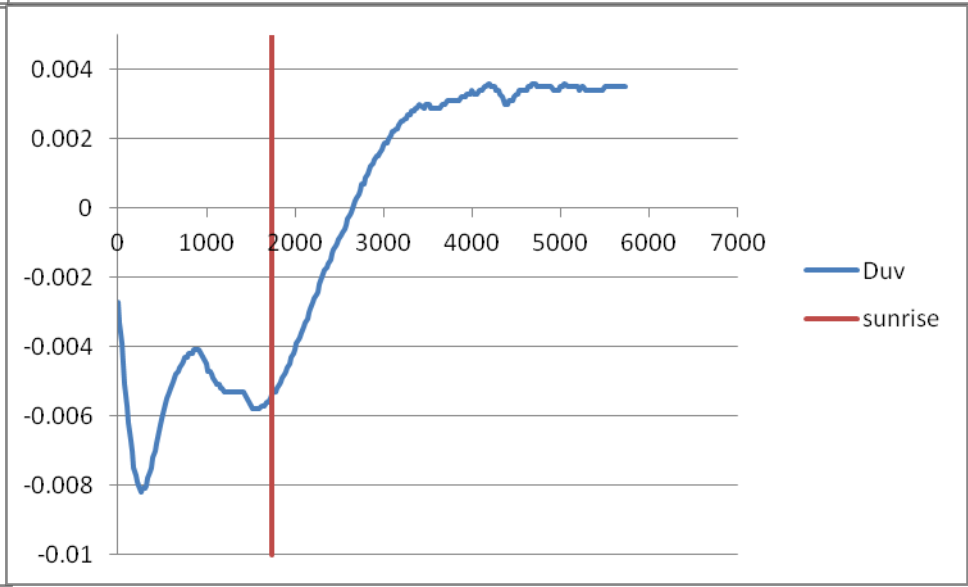
Solid line D50 fixed reference

Valley Summary – there's a lot going on









Summary

- A light source on the black body with high CRI is not the only definition of quality.
- Daylight is the gold standard for illumination and its seldom on the black body.
- Daylight is complex and changing
- Electronic illumination enables the reproduction of daylight in many forms
- Designer spectrums offer additional value
- There is gold in the gold standard

Light Beyond the Tube™

Thank You

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